PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference FP20995	FOR FURTHER ACTION	See Form PCT/IPEA/416
International application No. PCT/AU2005/000020	International filing date *(day/month/year)* 11 January 2005	Priority date *(day/month/year)* 2 February 2004

International Patent Classification (IPC) or national classification and IPC

Int. Cl.

G01M 11/02 (2006.01) ***A61B 3/12*** (2006.01) ***G01J 9/00*** (2006.01)

Applicant

IATIA IMAGING PTY LTD et al

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of 5 sheets, as follows:
      - [X] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
17 June 2005	09 January 2006
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer LYNN BLOOMFIELD Telephone No. (02) 6283 2851

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2005/000020

Box No. I Basis of the report

1. With regard to the language, this report is based on:

[X] The international application in the language in which it was filed

[ ] A translation of the international application into , which is the language of a translation furnished for the purposes of:

- [ ] international search (under Rules 12.3(a) and 23.1 (b))
- [ ] publication of the international application (under Rule 12.4(a))
- [ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

[ ] the international application as originally filed/furnished

[X] the description:

pages 1 – 13, 15 – 17 as originally filed/furnished
pages* 14 received by this Authority on 17 June 2005 with the letter of 17 June 2005
pages* received by this Authority on with the letter of

[X] the claims:

pages as originally filed/furnished
pages* as amended (together with any statement) under Article 19
pages* 18 - 21 received by this Authority on 17 June 2005 with the letter of 17 June 2005
pages* received by this Authority on with the letter of

[X] the drawings:

pages 1/5 – 5/5 as originally filed/furnished
pages* received by this Authority on with the letter of
pages* received by this Authority on with the letter of

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

- [ ] the description, pages
- [ ] the claims, Nos.
- [ ] the drawings, sheets/figs
- [ ] the sequence listing *(specify)*:
- [ ] any table(s) related to the sequence listing *(specify)*:

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- [ ] the description, pages
- [ ] the claims, Nos.
- [ ] the drawings, sheets/figs
- [ ] the sequence listing *(specify)*:
- [ ] any table(s) related to the sequence listing *(specify)*:

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims 1 – 17	YES
	Claims	NO
Inventive step (IS)	Claims 1 – 17	YES
	Claims	NO
Industrial applicability (IA)	Claims 1 – 17	YES
	Claims	NO

2. Citations and explanations (Rule 70.7)

The following documents identified in the International Search Report have been considered as relevant for the purposes of this report:

D1: US 6 331 059
D2: PRIMOT et al. Deconvolution from wave-front sensing: a new technique for compensating turbulence-degraded images.

Novelty (N), Inventive Step (IS)

D1 discloses an apparatus and method for compensating for the effect of aberrations in an optical system on an acquired image, and explicitly incorporates D2 as including the details of the calculations. The method of D2 includes simultaneously acquiring two images – one of a beam of light that is directed through the system and measured on a Shack-Hartmann wavefront sensing module, and the other a retinal image taken by a high resolution CCD detector. These documents are therefore limited to the use of a Shack-Hartmann wavefront sensor, and neither document discloses or suggests solving the transport of intensity equations to obtain phase data relating to the wavefront. Claims 1 – 17 therefore satisfy the criteria for novelty and inventive step.

the fundus is captured on a charge coupled device 62 and the entirety of the data captured by the charge coupled device 62 is transformed to remove the distortions or aberrations, the improvement in resolution of the image is significant, thereby providing an image which is of sufficient resolution to show details of the cones and rods of the fundus so that diagnosis as well as scientific research relating to the fundus of the human eye can be performed without the need for any invasive technique.

Figures 7A to 7E are photographs which show an application of the preferred embodiment of the invention.

Figure 7A is intended to represent a true depiction of fundus of a human eye. Figure 7B is an image which one would expect to obtain if the eye contains some aberrations caused by the lens and cornea as described above. As is apparent, the image in Figure 7B is very much blurred compared to the depiction in Figure 7A.

Figure 7C shows phase data which has been created using the algorithm previously referred to when applied to images from the reflected point source. If the eye was in perfect condition and a point source emanated from the fundus of the eye, the phase image in Figure 7C would be a perfect circle. However, because of the distortions, the wavefront itself has been distorted and therefore the image is not perfect. Because it is known that if there is no distortions, a perfect circular image emanating from a point source at the fundus or, in other words, a planar wave, would be received. A transformation can be determined to transfer the phase image in Figure 7C to what phase image would be expected if there were no aberrations or distortions. In the preferred embodiment of the invention, this is done by a point spread function which is shown in Figure 7D in which various pixels are provided with various intensities of light corresponding to the phase image of Figure 7C.

Claims

1. An apparatus for compensation for aberrations or distortions of an optical system, comprising:

means for directing a beam of light through the optical system;

detector means for detecting the beam of light at at least two different focal planes after the beam of light has passed through the optical system; and

processing means for receiving data relating to the light at the two different focal planes from the detector and for processing the data to produce phase data relating to the wavefront of the beam of light emanating from the optical system by solving the transport of intensity equation to enable a transformation to be determined for transforming the data relating to the detected wavefront to a predetermined reference, and for applying the transformation to an image which has passed through the optical system to remove aberrations or distortions introduced by the optical system.

2. The apparatus of claim 1 wherein the detector comprises a charge coupled device.

3. The apparatus of claim 1 wherein the apparatus includes a light source for shining a parallel beam of light through the optical system and a beam splitter for directing reflected light from an article travelling back through the optical system to the detector for detection.

4. The apparatus of claim 1 wherein the apparatus includes a lens for focusing light passing through the optical system so as to obtain an image of an article viewed through the optical system.

5. The apparatus of claim 1 wherein the data to which the transformation is applied is intensity data.

6. The apparatus of claim 5 wherein the application of the transformation comprises a deconvolution of the intensity data.

7. The apparatus of claim 1 wherein the transformation is a propagation of the wave from one image location to another.

8. A method for compensating for aberrations or distortions in an optical system, comprising the steps of:

shining light through the optical system;

detecting the light at at least two different focal planes after the light has passed through the optical system;

producing phase data relating to the wavefront of light detected by the detector at the two different focal planes by solving the transport of intensity equation;

determining a transformation to transform the phase data in accordance with a known reference data; and

applying the transformation to data relating to an image of an article produced through the optical system so as to remove the effects of aberrations or distortions of the optical system on that data.

9. The method of claim 8 wherein the data to which the transformation is applied is data relating to the image of the object so that the image of the object is produced free of distortions which would otherwise be introduced by the distortions or aberrations in the lens system.

10. The method of claim 8 wherein the detector comprises a charge coupled device.

11. The method of claim 8 wherein the data relating to the image is captured by directing a beam of light

through apparatus including a lens for focusing light passing through the optical system so as to obtain an image of an article viewed through the optical system.

12. A fundus camera for producing an image of the fundus of a person's eye, said camera comprising:

a detector for detecting at at least two different focal planes a beam of light passing through the cornea and lens of a person's eye and reflected from the fundus of the person's eye and again passing through the lens and cornea of the person's eye;

processing means for determining phase data relating to the wavefront of the light beam detected by the detector at the two different focal planes by solving the transport of intensity equation and for producing a transformation required to convert the phase data from that detected by the detector to a known reference data;

the detector also being for detecting a beam of light directed through a person's eye to obtain an image of the fundus and for producing phase data relating to that image; and

the processing means being for processing the phase data relating to the image in accordance with the transformation to transform the data relating to the image to compensate for aberrations and distortions introduced by the cornea and lens of the person's eye, and for producing a image of the fundus, which is therefore free of distortions and aberrations introduced by the cornea and lens of the person's eye.

13. The camera of claim 12 wherein the camera also includes a light source for producing the beams of light detecting by the detector.

14. The camera of claim 12 wherein the camera further includes a lens for focusing the beam of light towards the eye so that the beam of light which produces the image is

reflected from the fundus so as to provide an image of the fundus.

15. The camera of claim 12 wherein the camera has a monitor for displaying a image of the fundus.

16. Apparatus for determining the amount of distortion or aberration of a lens system, comprising:

means for directing a beam of light through the optical system;

detector means for detecting the beam of light at at least two different focal planes after the beam of light has passed through the optical system; and

processing means for receiving data from the detector relating to the beam of light at the two different focal planes and for processing the data to produce phase data relating to the wavefront of the beam of light emanating from the optical system by solving the transport of intensity equation and for determining the amount of aberration or distortion of the lens system relative to reference phase data.

17. A method for determining aberrations or distortions in an optical system, comprising the steps of:

shining light through the optical system;

detecting the light at at least two different focal planes after the light has passed through the optical system;

producing phase data relating to the wavefront of light detected by the detector at the two different focal planes by solving the transport of intensity equation; and

comparing the phase data with a reference phase data to determine the difference and therefore the aberration or distortions introduced by the lens system.